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Japanese Published Unexamined (Kokai) Patent Publication No. S61-104075; Publication Date: May 22, 1986; Application No. S59-221302; Application Date: October 23, 1984; Int. Cl.^{4}: C23C 14/54 14/30; Inventor: Hironobu Sato; Applicant: Hironobu Sato; Japanese Title: Ionka Jouhatsusokudo Seigyo Souchi (Controller for Ionizing Vaporization Velocity)

Specification

1. Title of Invention

Controller for Ionizing Vaporization Velocity

2. Claim(s)

1. A controller for ionizing vaporization velocity as in a vacuum vapor deposition thin film producing device that forms a vapor deposition thin film by heating and vaporizing a substance in a vacuum state, characterized in that an electrode that radiates specific thermionic current is provided in a location where particles to be vaporized from a vaporization source so that a substance vaporized from the vaporization source constantly keeps a specific film thickness for the purpose of ionizing the vaporizing particles uniformly or all the vaporizing particles; the vaporization velocity is specified using a portion of ionic current of the ionized particles.

2. The controller for ionizing vaporization velocity, as indicated in Claim 1, characterized in that the thermionic emission electrode is formed in a circular shape (refer to Fig.3) to make thermions radiated by a filament and a thermionic leading electrode spread on the center and obtain an electron density equivalent to the distribution density of particles

vaporized from the vaporization source; by these means, the vaporizing particles are ionized constantly at a specific ratio or entirely.

3. Detailed Description of the Invention

As for a method for determining the film thickness according to the period for vapor deposition while specifying the vaporization velocity as in a device for applying a coating a thin film on the surface of a sample within a vacuum state, this invention pertains to a device for specifying the evaporation velocity using ionic current of evaporating particles being ionized in advance.

These are two conventional methods for controlling the thickness of a thin film: a method for determining the thickness from a vaporized film; a method for determining the thickness of a film by the vaporizing period while specifying the vaporization velocity of a vaporization source. The former method is usually used for a quartz film thickness tester and a photo-interference film thickness tester. An electric signal obtained as a film thickness is not in the form of vaporization atoms or molecules, but it is a film thickness that is converted by a frequency or light from a detector of the tester. As this method does not control atoms and molecules per se, a thin film generating state cannot be determined. In addition, the detector is required to be replaced. In the recent years, it has been known about a thin film that a thin film forming process severely affects the growth of crystal and all performances. In order to avoid this problem, the latter method for producing a thin film is demanded. There are two means for the method: a sputtering using a Penning discharge; a measuring using ionic current that is generated during a vacuum vaporization. The sputtering means involves at a higher cost and is vapor deposition of neutral particles

alone since it is applied in a strong magnetic field. The means that uses the ionic current generated during evaporation generates extremely small ionic current at 10^{-5} to 10^{-6} A to cause a problem on a discharge that occurs at a vacuum state, thereby making it impossible to put an automatic control method for the vaporization velocity to the practical use.

With the method for ionizing particles vaporizing from the vaporization source by the invention, ionic current at several ten A is obtained even in a high vacuum. The problem due to the vacuum discharge will not occur. When a portion of the ionic current is used, a device for specifying the vaporization velocity of the vaporizing particles from the vaporization source is easily produced.

A condition necessary for the production of a vapor deposition thin film is to control the temperature of a vapor deposition surface and a surface condition. The temperature of the vapor deposition surface cannot be controlled to be specific at a state at which vaporizing particles at a high temperature are spread with no limitation. It is necessary for the particles to be supplied onto the vapor deposition surface by a required amount while specifying the vapor deposition velocity. An impurity-less state is created on the surface as impurities become cores for forming crystal. Various metals are supplied as needed. In this case, the bonding between metals seems to be more effective if the particles are in the form of ions for a production of a compound or alloy because the bonding energy is higher in an ion state than a non-vibration state of atoms.

The present invention is produced to specify the vaporization velocity of particles vaporizing from a vaporization source using a portion of ionic current of a device produced, having a specific relation between the ionic current and the vaporizing particles

by ionizing the vaporizing particles uniformly at a specific ratio or all the particles. The invention is applied to an ion plating method practiced in a reaction gas from a regular vacuum vapor deposition device (PAT filing: 57-151892), a method for producing monocrystal on a vapor deposition surface by more accurately controlling the temperature of the vapor deposition surface and a method for producing a compound by varying the ratio of ions of a plurality of vaporizing particles. In addition, the invention is used for producing a compound by varying the amount of electrons (PAT filing: 58-048359 and 58-063209). Therefore, the invention is necessary for production of materials endowed with new functions.

The detail of the invention is described hereinbelow with reference to the drawings.

Fig.1 is a block diagram illustrating a device of the invention. Reference number 1 refers to a vacuum container; 2 to an exhaust system to create a vacuum state; 3 to a sample to produce a vapor deposition thin film; 4 to a substance to be vaporized; 5 to a plurality of furnaces to vaporize a variety of substances; 6 to an electron gun; 7 to a thermionic emission electrode filament having a circular structure, which ionizes vaporizing particles uniformly or all the particles. The filament 7 has a structure such that thermions become specific at a control power source 17 via a transducer 16. In Fig.1, a constant voltage adjuster with high precision is used as the power source 17. The substance 4 vaporized from the vaporization furnace 5 is ionized by electrons when it passes the center of the electrode filament 7 that is emitting the electrons for ionization, and a major portion of the ions reaches the vapor deposition sample as it is. Ions generated in the vicinity of the electrode 7 reach the electrode 7 and become ionic current.

By these means, the vaporization amount is read using an ammeter 12. Since a control power source 15 is automatically controlled so that the indication of the ammeter 12 becomes a predetermined value, the vaporization velocity of the vaporizing substance 4 becomes specific. When a shutter 8 is opened, the vaporizing particles 4 are vapor-deposited on the sample 3. The relation between the amount to be vaporized and the time period is measured and calculated in advance using vapor deposition film thickness measuring devices 10 and 11. An ammeter 18 is used for measuring the ratio of electrons vapor-deposited on the sample 3 to ions and is an adjuster that determines the ratio as needed by a combination between a resistor 20 and a cell 21.

Fig.2 illustrates current that runs in the ammeter 12 when the device of Fig.1 is actually operated, as indicated by a curve a, whereas current that runs in the ammeter 18 is indicated by a curve b. The horizontal axis indicates an elapsing time during the operation. Reference symbol A refers to a state at which thermions are emitted from the electrode 7 while initially supplying a power source to the control power source 17. When the control power source 15 is operated in a location B, the vaporizing substance 4 is vaporized and becomes ions after passing the center of the thermionic emission electrode 7. A majority of the ions reaches the vapor deposition substrate 3. A portion of the ions also reaches the electrode 7 and flows into the ammeter 12. The control power source 15 is then operated until obtaining a predetermined value of the ammeter, and the value becomes specific at a state C.

Fig.3 is a structural view illustrating the thermionic emission electrode filament 7 seen from above. Reference numbers 71 and 72 refer to electrode rings for supplying a power to the filament 7. The electrode ring 72 has a semi-circular structure to direct

thermions to the center by an electrostatic means. Reference number 73 refers to an electrode for the electrode ring 71; 74 to an electrode for the electrode ring 72; 75 to insulating glass; and 76 to an electrode for leading thermions from the filament. A power source 13 is connected between the filament 7 and the electrode 76 via the ammeter 12. The electrode 76 is grounded. Reference number 16 refers to a transducer for supplying a power to the filament 7.

Fig.4 illustrates the density of thermions at the cross-sectional view cut along an XX' line on the center of the electrode of Fig.3 and the density of vaporizing particles passing the XX' line of the cross-section from a vaporization source. A curve d indicates the density of thermions and constantly obtains constant current. A curve c indicates the density of vaporizing particles and increases and decreases by the amount to be vaporized. Electrons emitted from the filament 7 toward the center of the electrode collide against (or are absorbed in) vaporizing and passing particles, thereby splashing the electrons and ionizing the particles. On the other hand, it is known that the electrons increase at every collision to generate an electron decay, thereby ionizing the vaporizing particles constantly at a specific ratio or all the particles. As in the method, since the amount of the vaporizing particles is measurable if ionic current is measured when the structure and the pressure of vacuum do not change, a portion of the entire ions is measured using ionic current that runs into the filament 7 and the surrounding electrode to achieve a control of the vaporization velocity.

As described above, the invention that is capable of performing an automatic control using an ionizing means for the vaporization velocity of a vaporization source, which is not previously possible, demonstrates the following advantages:

1. uniformizing the temperature of the sample; 2. making it possible to produce vapor deposition films with different components or add a slight amount to the sample; 3. making it possible to control the initial condition of the vapor deposition as well; 4. using ions for the vapor deposition; 5. making it possible to apply vapor deposition even at a high vacuum state; 6. using a detector that has a dirt proofing in the vacuum and that can be used semi-permanently; 7. applying vapor deposition uniformly by changing the sensitivity of an amplifier even though ionization differs by the substances; 8. controlling the film thickness in a shutter period; 9. achieving an excellent reproducibility; and 10. having an easy connection to a computer.

4. Brief Description of the Invention

Fig.1 is a block diagram illustrating a working example of the invention; Fig.2 a control curve view illustrating the operation; Fig.3 is a diagram illustrating a thermionic emission electrode as in the working example; Fig.4 is a characteristic curve view illustrating the density of vaporizing particles at a cross-section cut along an XX' line on the center of Fig.3 and the density of thermions emitted.

1...Bell jar

2...Exhaust system

3...Sample

4...Substance

5...Electrode

6...Electron gun

7...Filament

8...Shutter

9...Heater

10...Film thickness tester

11...Film thickness tester

12...Ammeter

13...Cell

14...Transducer

15...Control electrode

16...Transducer

17...Control power source

18...Ammeter

19...Diode

20...Variable resistor

21...Cell

22...Power source

71...Electrode ring

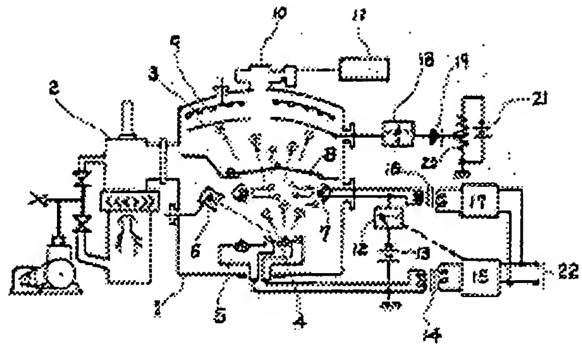
72...Electrode ring

73...Electrode

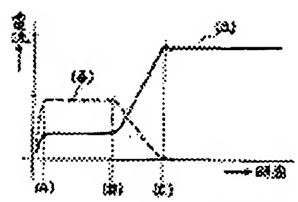
74...Electrode

75...Insulator

76...Anode



第1図



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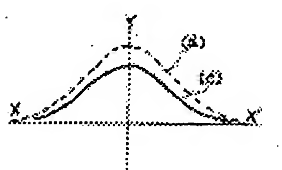

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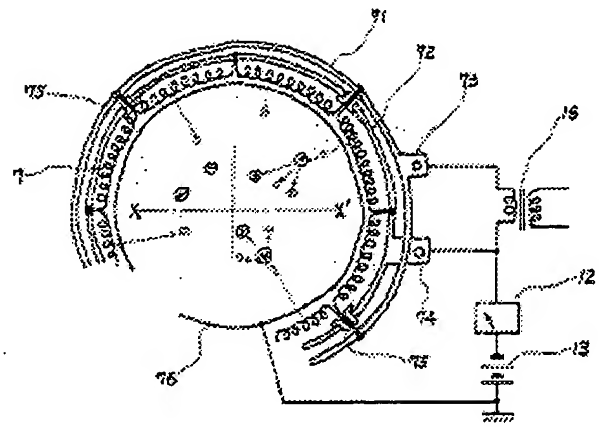

第3図

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